Space Weather Technical Forecast

Issued on Friday, 31 March 2023 at 12:08 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of both Minor Radio Blackouts and Minor Geomagnetic Storms peaking today. Active electron fluence becoming Likely into new UTC week.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity reverted to Low over the past 24 hours, with a declining background level of X-ray flux and only occasional small C-class flares recorded at GOES16 and 18. The peak flare of the period was a C4.4 at 31/0909UTC from near AR3260 on the northwestern limb. Another event of note was a C2.8 at 30/1948UTC, with this produced by the relatively unassuming AR3262 on the southwest of the disc, which was at that point an Hsx/Alpha. This event produced a minor dimming in AIA211 imagery and small, localised EUV wave. It is not certain that this event translated into any (Interplanetary) Coronal Mass Ejection (CME), however two candidates were seen heading westwards on evening coronagraph imagery. These have been analysed and are both misses ahead of Earth in its orbit. The emission location of the earlier of the two events could not be determined, but has been inferred from analysis as likely narrowly far-sided.

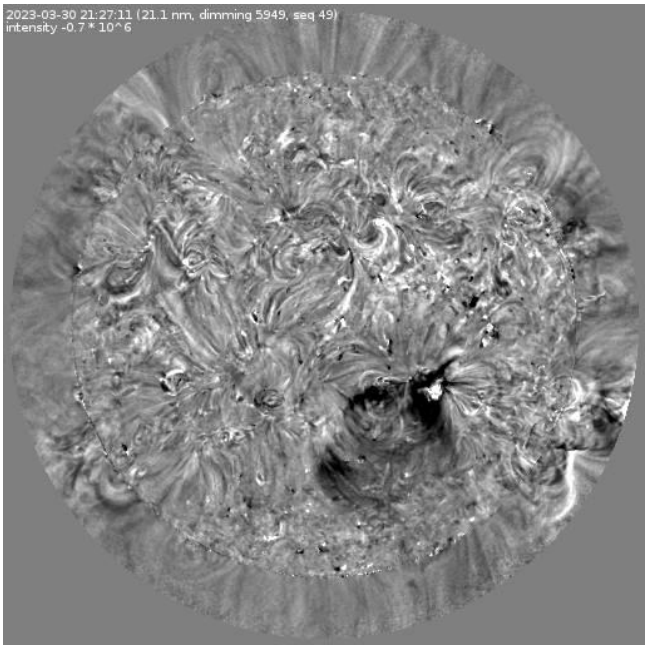

Figure 0: Time-integrated AIA211 dimming tied to the C2.8 flare from AR3262 at 30/1948UTC. This event has been tentatively linked with some of the ejecta seen heading westwards on coronagraph imagery in the following UTC evening – this has been determined to miss Earth in any case. Image processing courtesy of SIDC ROB.

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The above sunspot was one of five numbered regions on the disc, with a new unnumbered small bipolar group also developing to the immediate west of AR3264. All of the numbered groups were unipolar and stable, else bipolar and in apparent decay. Finally, the most active sunspot of recent days, Ex-AR3265, became indistinct as a plage remnant on the southwestern solar horizon, although this plage may still contain its small trailing spots given the unfavourable viewing angle for analysis.

Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 by ACE and DSCOVR, showed a CIR immediately preceding the 24-hour period almost exactly giving way to the CH88/- fast wind as the period began at 30/1200UTC. The phi angle was accordingly negative (towards the Sun) throughout.

The solar wind speed rose from Slightly Elevated near 450km/s to rise to a brief peak in the high 600s of km/s and Strong levels, eventually moderating to Elevated levels by the period's end. The solar wind density fell from around 10ppcc to low single figures as the fast wind evolved, while the IMF showed an erratic falling tendency from 10nT. The north-south component ranged between +5 and -7nT, but was mostly anti-aligned with Earth's field to greater geomagnetic effect.

The result of the above solar wind measures was for Quiet to Minor Geomagnetic Storm G1 conditions, with a provisional Kp of '5-' recorded in the 18-21UTC interval. This also tallied with a provisional Kgbi of '6-' in the same interval, with the H-component at BGS's Hartland magnetometer seeing an 80nT impulse from 30/1945UTC.

Energetic Particles / Solar Radiation: A slight high energy proton enhancement (greater than 10MeV) was visible at GOES16 as a result of the 30/0737UTC M5.4 flare from (now Ex-)AR3256, with 10MeV protons peaking at roughly half a pfu (where S1 is 10pfu) before declining to Background during the first half of the current 24-hour reporting period.

The high energy electron flux (greater than 2MeV), as measured at GOES16 showed a greatly attenuated diurnal oscillation versus previous days, with a range between Moderate and Normal Background. The peak flux was 942pfu at 30/1455UTC. The associated 24-hour fluence started the 24 hours above the Active (1e8 integrated pfu) threshold, but then declined through the day, recording 3.14e7 integrated pfu at 31/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries an initial Chance of further M-class flares as the trailing portion of AR3256 straddles the southwest limb. The risk of further such events should then sharply decline, with an uncertain degree of compensation possible from (up to six) arriving east limb regions. The latter do not feature in the probabilities, pending arrival for analysis.

Solar Wind / Geomagnetic Activity: A re-analysis of a portion of the 29 March prominence eruption from the southeastern limb now presents a Slight Chance of glancing incidence in the UTC day of 03 April, although the deterministic MOSWOC Enlil run has a miss. This is the only CME to possibly feature in the forecast at present.

The Earth is otherwise experiencing a fast wind from CH88/-, which is likely to bring Strong windspeeds into the coming UTC weekend before waning into the start of the new working week.

There is a Chance of Minor Geomagnetic Storm G1 peaking on day one, Friday 31 March, perhaps surviving as a Slight Chance on Saturday before largely Quiet conditions establish through Sunday 02 April. There is then a further Slight Chance of G1 should the 29 April CME

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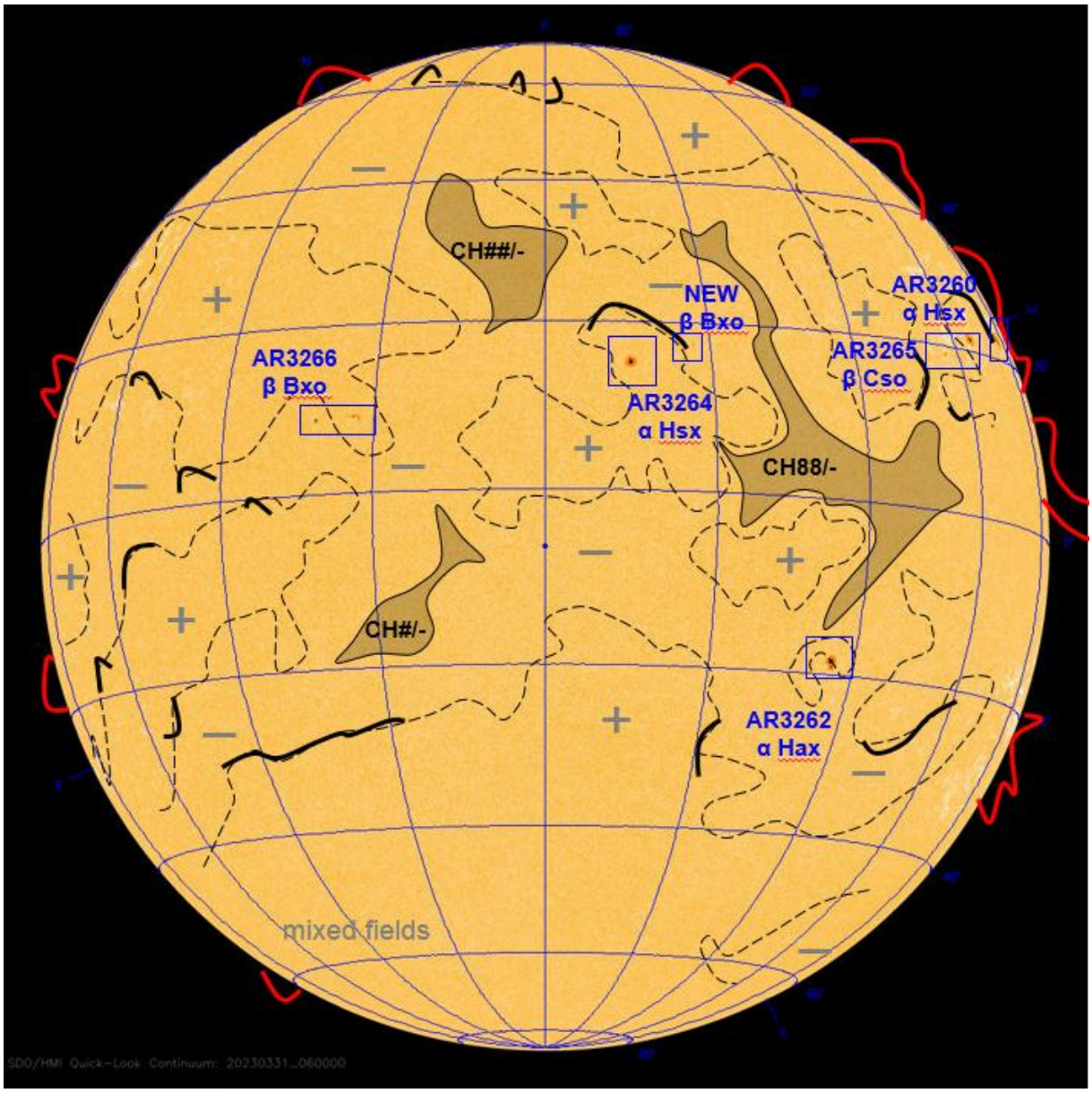
glance Earth on 03 April.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux carries a Slight Chance of breaching S1 given the history of capability from AR3256 and this spot group's remaining in a geoeffective location for at least the start of the four-day forecast period.

The high energy (greater than 2 MeV) electron flux is expected to be suppressed at GEO by geomagnetic activity from CH88/- in the near-term, but is considered Likely to recover to breach Active 24-hour fluence later in the UTC weekend and perhaps the new week, should the potential CME glance not materialise.

Figure 1. Solar Analysis Valid 31/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Met Office Space Weather Technical Forecast

Geomagnetic Storms:

A re-analysis of a portion of the 29 March prominence eruption from the southeastern limb now presents a Slight Chance of glancing incidence in the UTC day of 03 April, although the deterministic MOSWOC Enlil run has a miss. This is the only CME to possibly feature in the forecast at present.

The Earth is otherwise experiencing a fast wind from CH88/-, which is likely to bring Strong windspeeds into the coming UTC weekend before waning into the start of the new working week. This feature is rendered more potent by its recent habit of an anti-aligned Bz component with Earth's field, as well as its intensity and our proximity to the equinox - these all factor into the slightly longer tail of G1 risk than would normally be the case for a maturing coronal hole (i.e. the risk extends into Saturday 01 April).

There is a Chance of Minor Geomagnetic Storm G1 peaking on day one, Friday 31 March, perhaps surviving as a Slight Chance on Saturday before largely Quiet conditions establish through Sunday 02 April. There is then a further Slight Chance of G1 should the 29 April CME glance Earth on 03 April.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	50	20	1	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
30/1013	Partial	Prominence	SE limb	231	03/0001UTC	Glancing blow, most likely a miss

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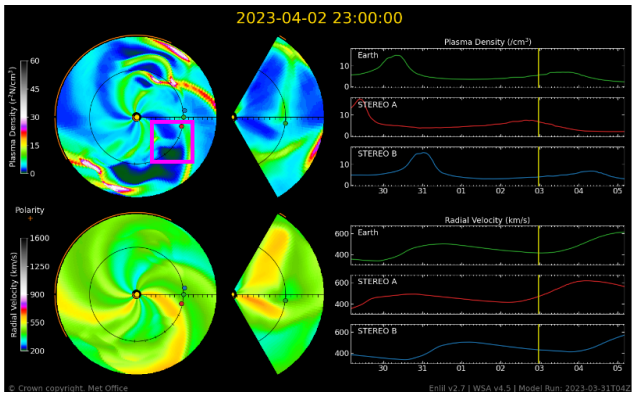
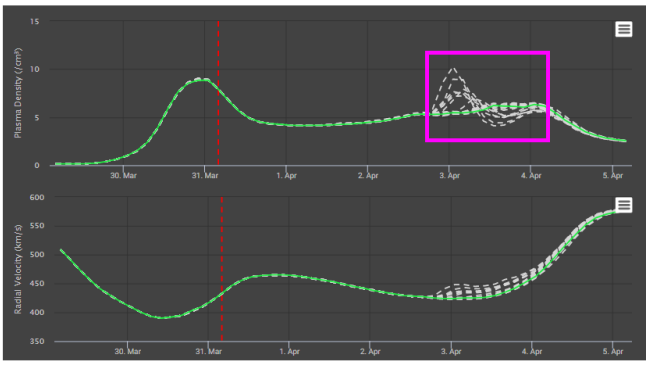
Figure 2: Latest MOSWOC Enlil run showing some ensemble members as indicating a glancing blow from part of the 29 March southeastern limb prominence eruption. Notice that the deterministic is unmoved, and this remains the preferred forecast.





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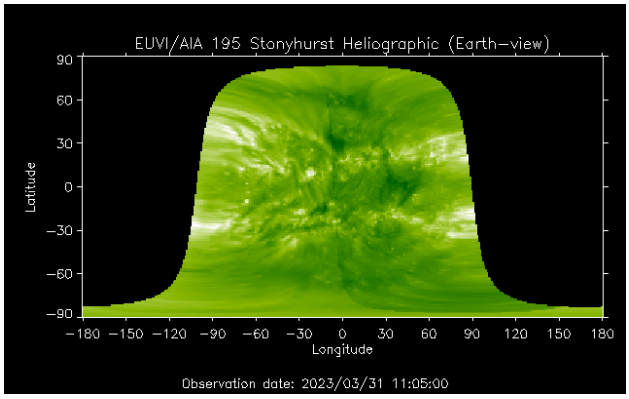
Radio Blackouts - X-Ray Flares:

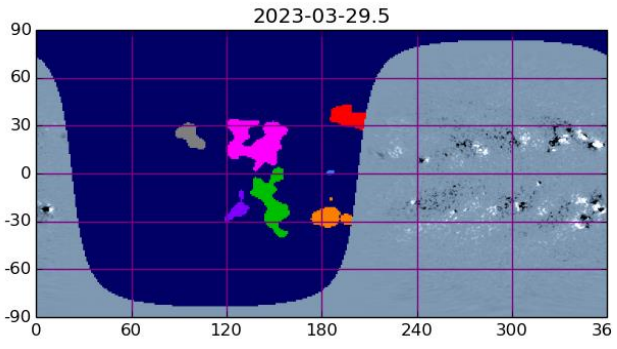
The four-day forecast period should see a step change within day one as the recent large sunspot group AR3256 departs from the Earth-facing side. This will be joined into the coming UTC weekend by many of the remaining front side cohort, such that only relatively few, simple regions remain.

Meanwhile, in the east, up to six returning regions may arrive, although there are no major signs of increased activity here from STEREO A EUVI imagery, soundings or flux looping from beyond the limb. These regions will be assessed as and when they present for analysis, and the net risk of flares is therefore downward over the period.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	No	25	10	10	5
Very Active	**R3 to R5 X**	No	10	1	1	1

Figure 3: STEREO A EUVI195 imagery, showing minor bright flux on the approaching eastern limb (-90 degrees), with recent far-side soundings indicating similar arrivals (orange and red appearing to be largely – if not entirely - plage)





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Solar Radiation Storms - (High Energy Protons):

While no recent S1-level enhancements have been recorded, AR3256 has delivered a sub-S1 enhancement with an M5 flare. Given that this sunspot has produced at least X1-level activity while further east, there is considered a slightly raised risk of solar radiation storms should it flare appropriately in the near-term - while it remains near the western solar horizon. This group is by far the largest contributor to the whole-disc probability, and this daily slight chance should therefore recede in tandem with its disappearance further round the western horizon.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	5	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Past three days in X-ray flux at GOES16 (top), and resulting high energy proton flux at GOES16 (bottom). Note the X and M-class flares from AR3256, the last of which delivered a short-lived sub-S1 scale enhancement. This has now faded to background.

High Energy Electrons Event (≥ 2MeV):

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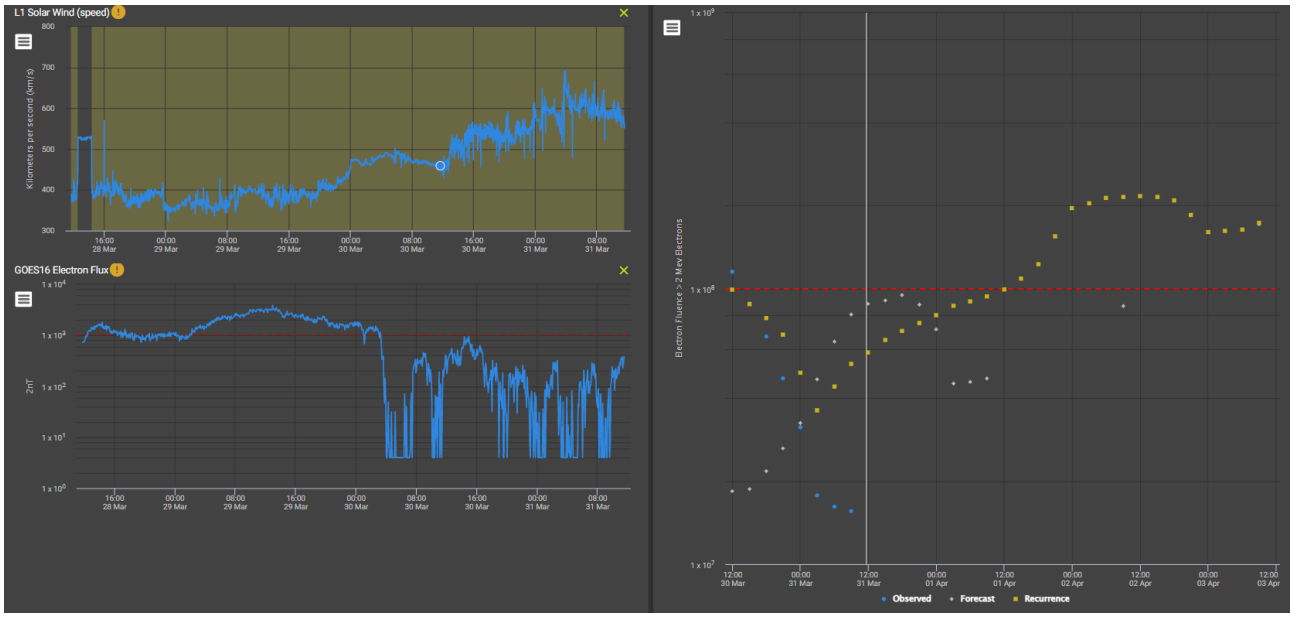
The diurnal flux oscillation at GEO has been significantly attenuated by geomagnetic activity from the CIR and coronal hole fast wind from CH88 in the past 36 hours. Flux levels are likely to remain suppressed into the coming UTC weekend while the fast wind remains in place, but are expected to react strongly upwards once the brakes of geomagnetic activity are lifted later in the weekend and into the new week.

MOSWOC REFM is perhaps a little muted in its expected response, with something more similar to persistence preffered, whereby fluence levels should exceed Active by the end of the weekend, saturating at their new level into Monday 03 April. There is a slight question mark as to the presence and effect of any glancing blow from a CME on Monday 03 April, although the most likely course of events is that this CME will miss to no effect of electrons at GEO.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^{8}$**	Yes	1	25	70	60
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	5	5

Figure 5: Clockwise from top left: Three-day L1 solar wind speed from ACE; MOSWOC REFM, showing 24 hours of observed fluence to 31/0900UTC in blue, persistence in yellow and forecast in white dots. The persistence is the preferred scenario at present. Finally, three-day GOES16 high energy electrons are shown lower left, with their oscillation sharply attenuated by the arrival of geomagnetic activity from the CH88/- fast wind.



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